The U.S. Navy Meteorological and Oceanographic Systems Program

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INTRODUCTION

The Oceanographer of the Navy is responsible to the Chief of Naval Operations for managing the Navy's Meteorology and Oceanography (METOC) programs. Under the policy guidance and resource sponsorship of the Oceanographer, the METOC Systems Program Office (PMW 185) of the Space and Naval Warfare Systems Command (SPAWAR), oversees the development, acquisition and life cycle support of all METOC systems and associated applications software, and also serves as his METOC systems architect. The METOC systems under the purview of PMW 185 directly support the Commander, Naval METOC Command concept of operations. This paper will examine how METOC support is developed and managed within the Navy, describe the major METOC systems that are in development and/or procurement and the associated RDT&E that supports them.

All through the cold war and into the early 1990s, the U. S. Navy focused on operations in the "blue waters" of the world - that is in the open oceans - against a strategic threat posed by a bloc of communist nations led by the Soviet Union. For the Navy, countering the particular threat represented by the Soviet nuclear powered ballistic missile submarines was foremost. With the demise of the political regime in Eastern Europe, the Navy shifted its focus towards the littoral and hinterland regions of the world, where the threat evolved into one of a major regional conflict or smaller scale "brushfires" - scenarios involving one or more third world countries. The challenge for the METOC community, given this new Navy focus, is incalculably more complex. Figure 1 provides a comparison between the deep ocean where, in the past, acoustics was the principal concern, and the coastal regime which is complicated by many interactive factors.

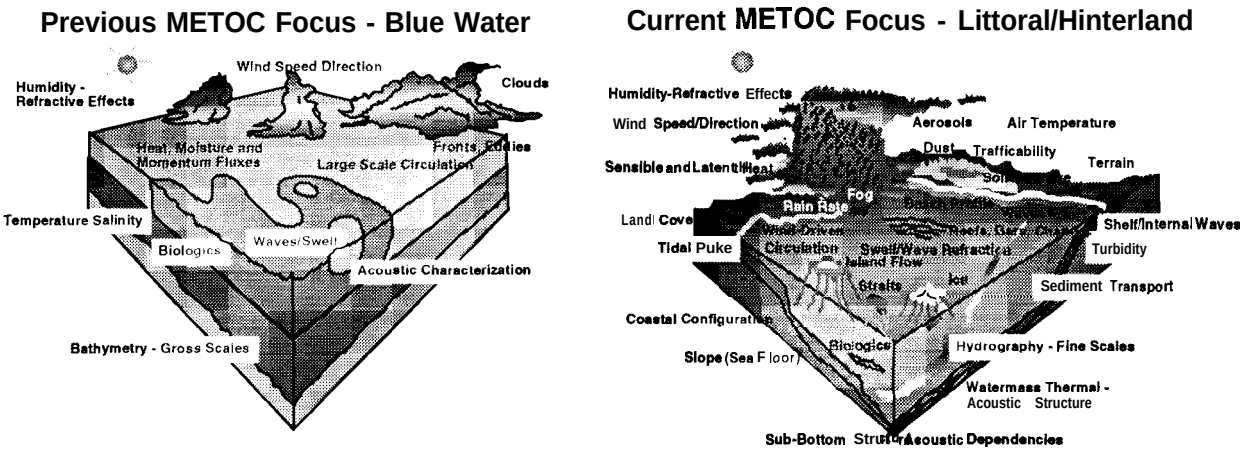

Figure 1. Side by side comparison of METOC features of "Blue Water" and coastal areas.

In order to respond to the requirements that this new focus presents, the Navy METOC Systems Program Office has developed a concept for, and is working toward achieving, a seamless architecture. This architecture, schematically depicted in Figure 2, is based on developing global numerical model products and data at central site computing facilities and transmitting them through the theater METOC centers to the Tactical Environmental Support System (TESS) afloat. Finally, individual fleet and Marine Corps units are provided highly specialized METOC information which assists them in decision making. Locally acquired data can be infused anywhere along the process to add value to the final products.

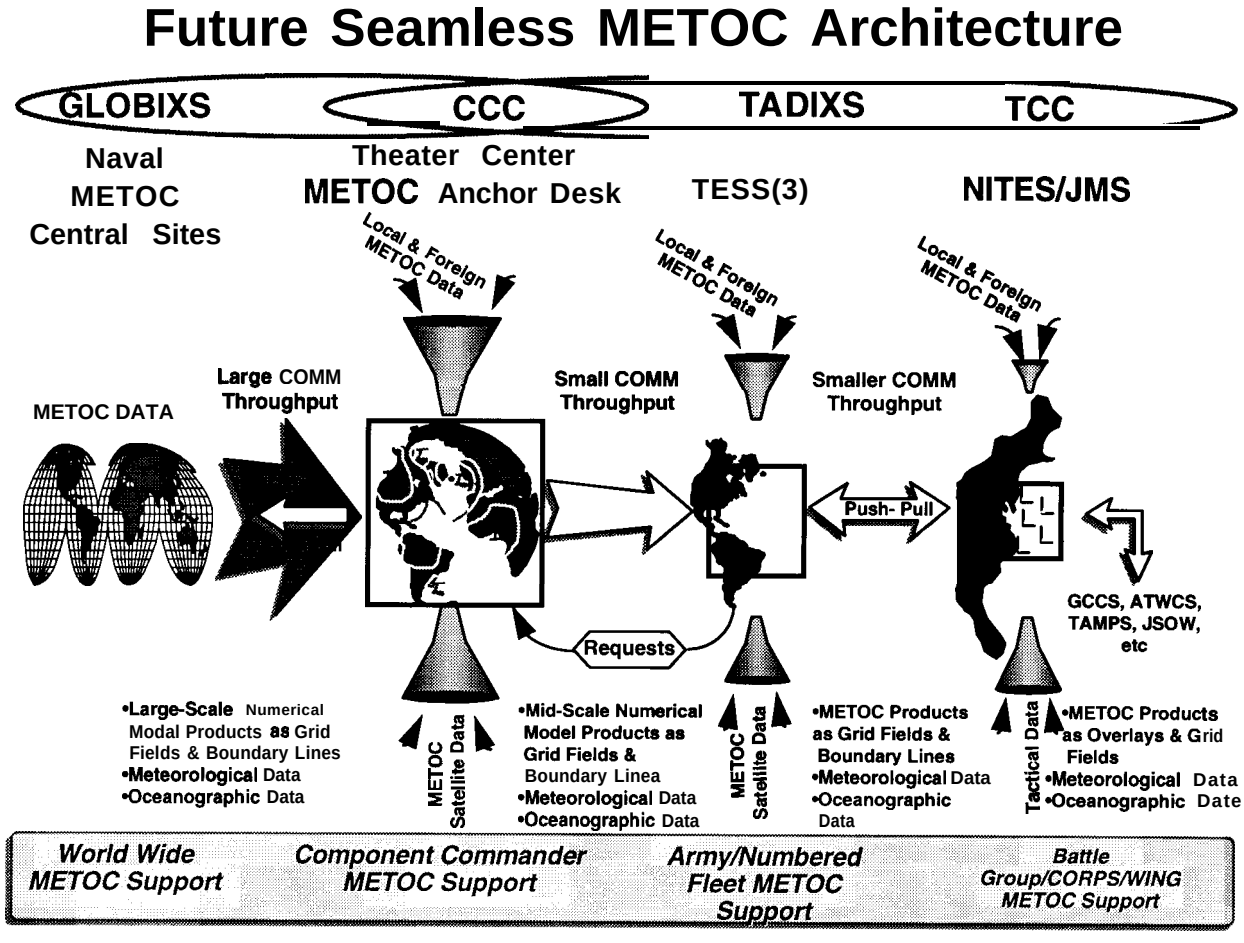

Figure 2. Schematic of Future Seamless METOC Architecture.

TESS

The system that will serve as the cornerstone of METOC support for the future is the TESS (Next Century) - TESS(NC). TESS(NC) will be a computer-based, interactive environmental data receiving, storing, processing and display system to be installed on major Navy ships and shore stations. TESS(NC) will dramatically upgrade and expand current capabilities and will be fully compliant with evolving Joint Command, Control, Communications and Computers and Intelligence, Surveillance and Reconnaissance (C4ISR) architectures.

TESS(NC) will feature a number of cornerstone applications that will allow on-scene METOC data assimilation and analysis, as well as a real time characterization of the electromagnetic, electro-optical and acoustic properties of the battlespace. TESS(NC) will exploit emerging PC technology and use commercially developed, off-the-shelf software, wherever possible. Figure 3 depicts some of these TESS(NC) features.

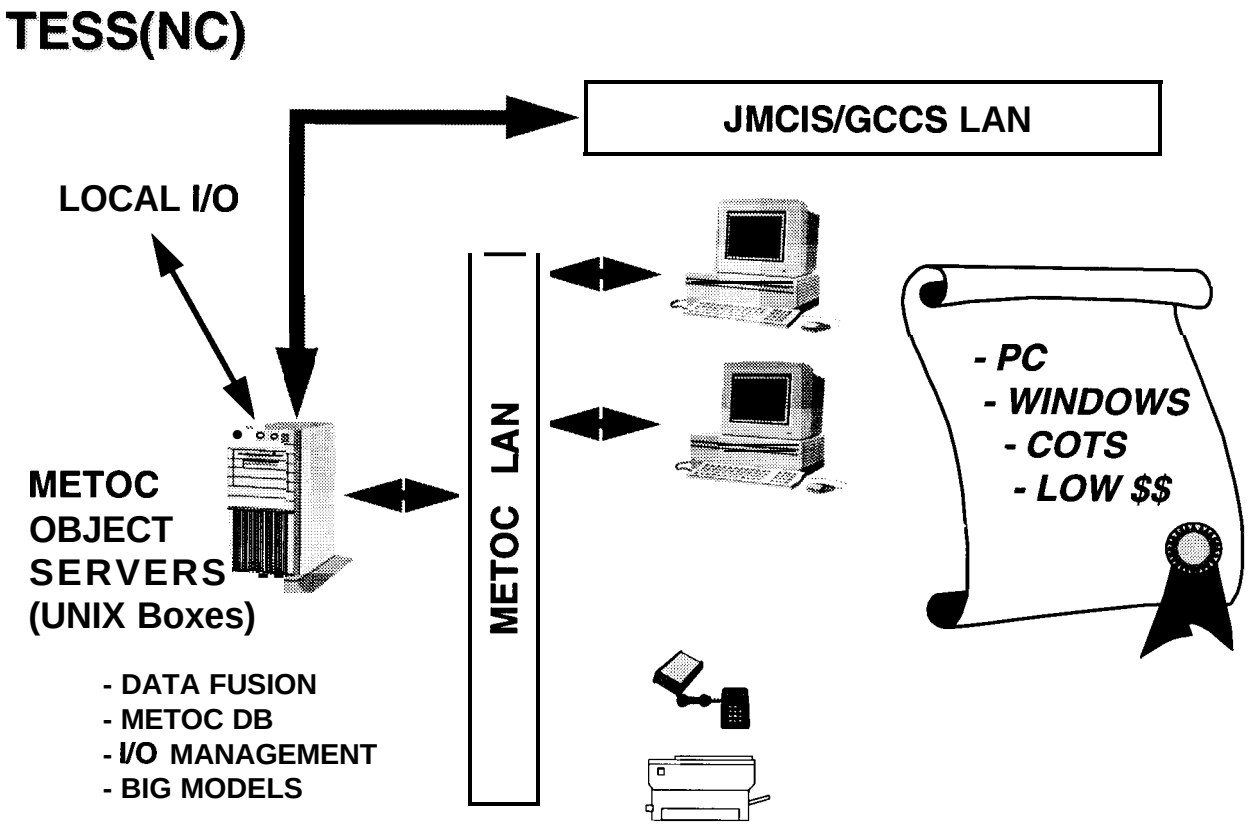

Figure 3. Schematic depicting TESS(NC) features. Locally acquired METOC data is fused with model output data in powerful workstations. User interfaces will be high end PCs. METOC data and products will then be distributed via the ship's LAN.

As TESS becomes fully integrated into the Joint Maritime Command Information System (JMCIS)/Global Command and Control System (GCCS), the METOC data and products provided will then more fully permit assessments and predictions of the effects of the environment on Battle Group, friendly, and enemy units, sensors, weapons, and communications.

SMOOS

The Shipboard Meteorological and Oceanographic Observing System (SMOOS) is a suite of sensors designed to provide automatic and continuous readouts of local air/ocean observations. This data is sent directly to the TESS database. The suite has been installed aboard all TESS-capable ships and automatically provides METOC data via digital interfaces. The baseline consists of five sensors that measure: 1) air temperature and dewpoint; 2) sea

surface temperature; 3) cloud height; 4) atmospheric pressure and; 5) visibility and precipitation. In addition, TESS is connected to the shipboard anemometer to provide wind speed and direction. A program to provide replacement sensors for SMOOS - SMOOS(R) will facilitate the introduction of new sensors in an evolutionary manner, as they become available. Commercially available, highly automated sensor packages for surface combatant ships have been extensively tested at sea aboard the RV Pt. Sur and the USNS SUMNER. It is anticipated that SMOOS(R) will be fielded in the FY98-99 timeframe.

AN/SMQ-11

The AN/SMQ- 11 is the environmental satellite receiver-recorder for use aboard selected Navy ships and METOC activities ashore. The antenna has recently been significantly reduced in weight and size by the Naval Air Warfare Center, Aircraft Division, Indianapolis. The AN/SMQ- 11 is capable of receiving data from the Defense Meteorological Satellite Program (DMSP) satellites, the NOAA TIROS-N (High Resolution) satellites and the geostationary (GOES), METEOSAT and GMS satellites (WEFAX only). In addition, the system can provide black and white hard copy prints of the imagery transmitted by these satellites within three minutes of the conclusion of the transmission. Data retention on magnetic tape permits automatic archiving of 14 consecutive satellite passes for subsequent enlargement and/or enhancement without operator intervention. The AN/SMQ- 11 digitally interfaces with other systems such as TESS. It is currently being modified to copy the GFO datastream (Satellite Data Record) and convert it to an Environmental Data Record of sea surface topography. Procurement of 75 AN/SMQ- 11 units was completed last year, with 32 slated for ships, and 43 for shore activities. A significant computer upgrade to the AN/SMQ- 11 is underway whereby the processing units within the two cabinets will be replaced by state-of-the-art computers, providing a new color monitor capability. This upgrade will allow the system to be merged with TESS and NITES over the next couple of years. Figure 4 highlights the features of the AN/SMQ- 11 hardware upgrade.

NITES

The Navy Integrated Tactical Environmental subsystem (NITES), being fielded as a JMCIS segment, is designed to meet current and all known future METOC support requirements of Navy Command nodes afloat and ashore and on non-TESS equipped ships. The current version includes grid fields and overlays, maintains a METOC observational database and features limited Integrated Refractive Effects functionality to produce EM coverage and threat diagrams. In the near future, NITES software will include additional products such as wind and high seas warnings and horizontal weather depictions, as well as management of frequently updated METOC digital data, to use as inputs to mission planning systems and decision aids.

ASOS

The Automated Surface Observing System (ASOS) is an interagency program of the National Weather Service, Federal Aviation Administration and the Navy. It consists of a state-

of-the-art suite of eight electronic sensors which are connected to a high speed processor. The system measures, processes and creates surface observations of

- precipitation
- wind speed and direction
- temperature and dew point
- air pressure
- visibility (fog and haze)
- cloud height

Of the total procurement of 76 Navy systems, 45 have been installed and are operational at Naval and Marine Corps facilities. Installations should be completed by the end of FY 97. Figure 5 depicts a typical ASOS sensor installation at an air station.

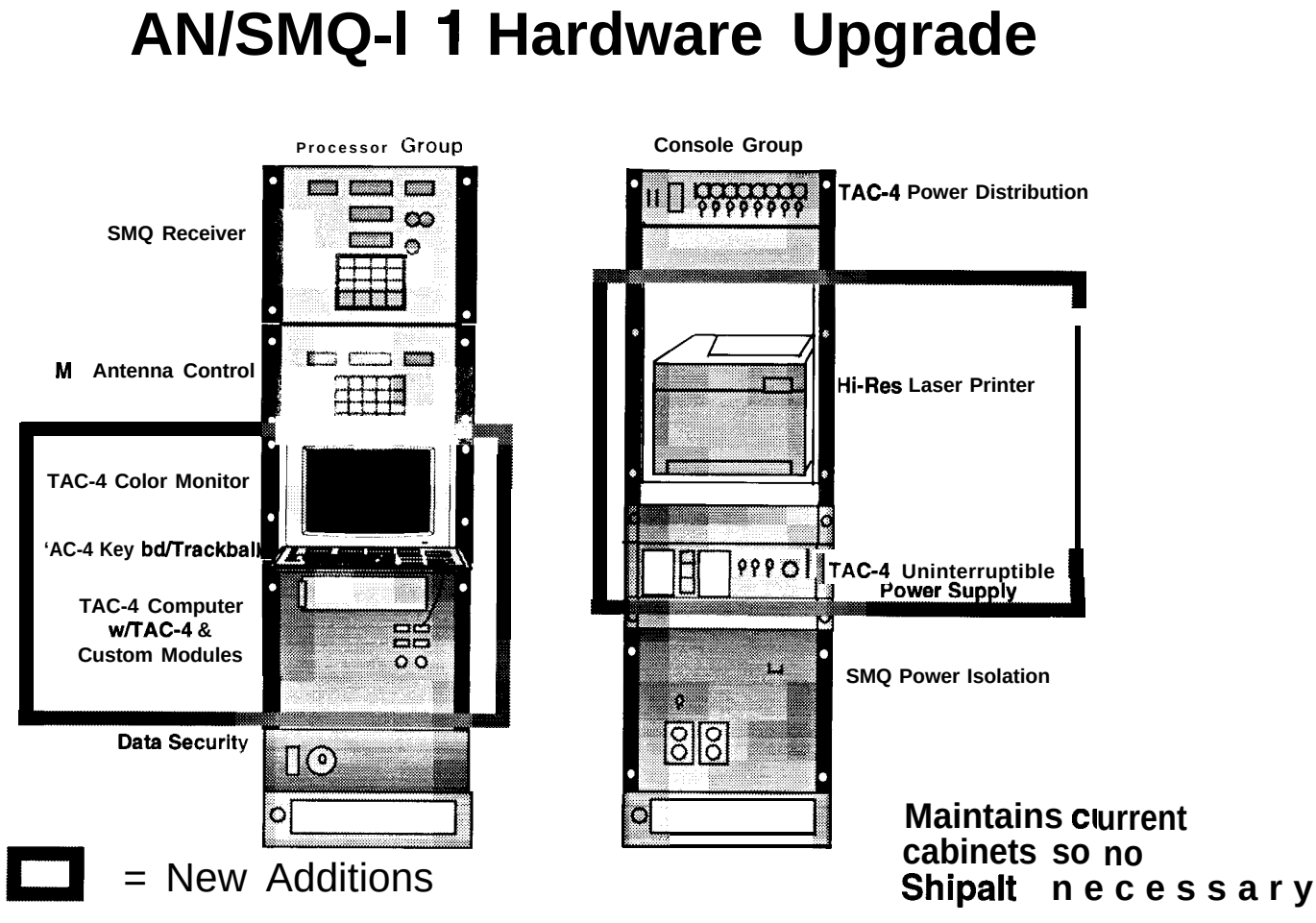

Figure 4. AN/SMQ-11 hardware upgrade, featuring the TAC4 and laser printer additions.

NEXRAD PUPS

The joint inter-agency Next Generation Weather Radar program is fielding systems that exploit Doppler radar technology for continuous wide area surveillance of potentially hazardous weather conditions. Navy and Marine Corps forecasters on watch at some 44 air facilities within the United States are now able to select products for display and printing on their principal user processors (PUP). Installation of the last few systems was completed last year. These products, along with data derived from local meteorological sensors and communications links, enable forecasters to prepare and disseminate more accurate and timely local weather forecasts and warnings, especially those where potentially hazardous weather is involved. Figure 6 depicts a NEXRAD radar tower and a typical PUP installation.

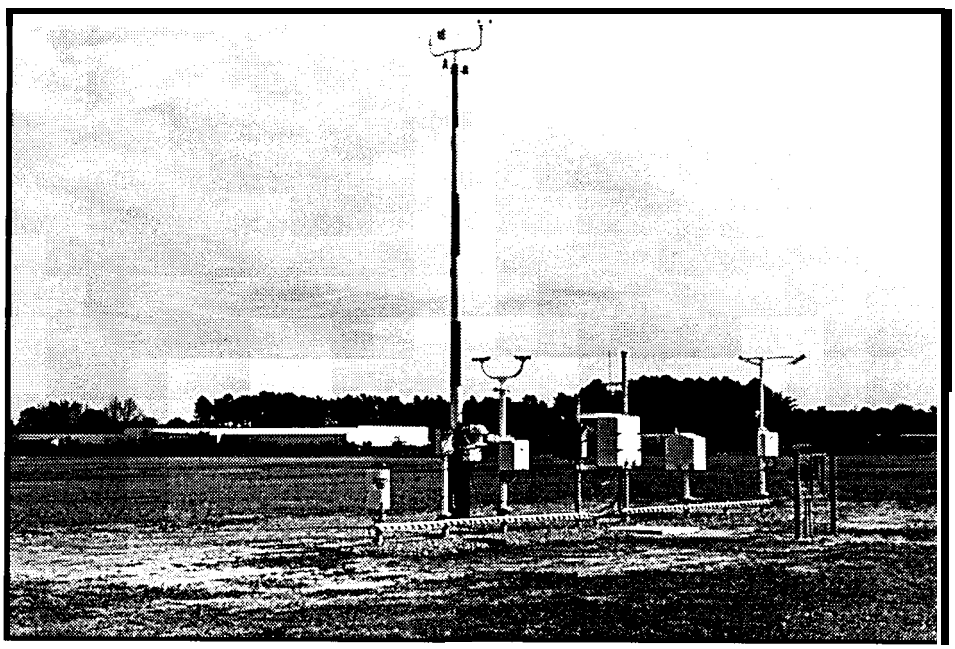

Figure 5. Typical ASOS installation at a Naval Air Station in CONUS. A total of 75 units are to be procured by the Navy.

Supplemental Weather Radar

As discussed above, NEXRAD PUPS have been procured to meet Navy needs for improved detection and surveillance of hazardous weather. However, a number of Navy and Marine Corps Air Stations lie outside the NEXRAD network. These activities currently have either inadequate radar surveillance capabilities or none at all. However, commercially available weather radars could provide sufficient coverage for these activities. Based on this need, an Operational Requirements Document for procurement of the Supplemental Weather Radar was approved in April and the Request for Proposals was released earlier this summer. Contract award is expected to be made by the end of this fiscal year with deliveries commencing shortly thereafter. The first two systems will be installed at NAS Fallon, NV and Guantanamo Bay, Cuba in the March 1997 time frame, for design test and evaluation. The remainder of the

systems will be installed at NAVSTA Rota, NAVSTA Diego Garcia, NAS Souda Bay, NAS Sigonella, NAVBASE Yokosuka, MCAS Iwakuni and NTTU Keesler AFB by June 1998.

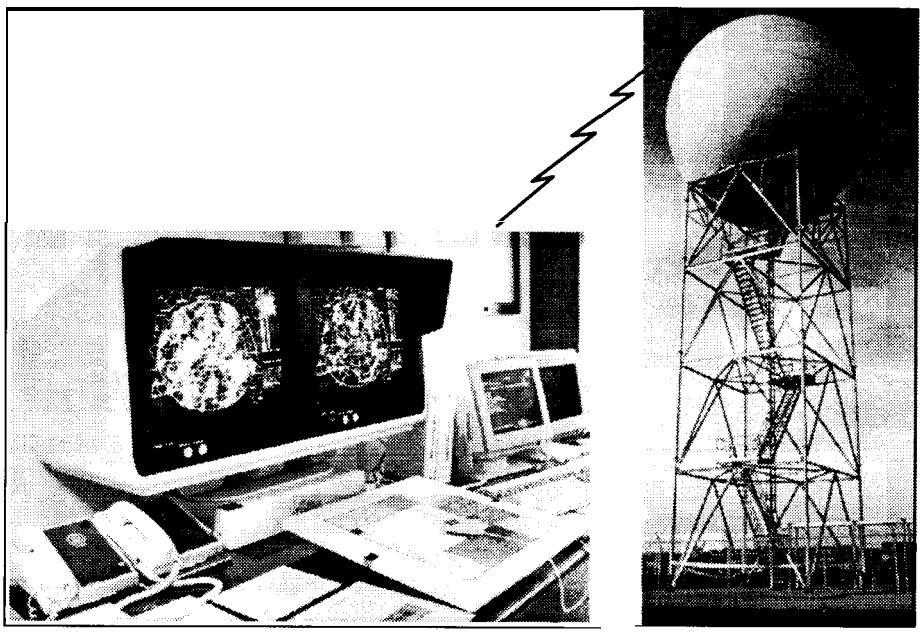

Figure 6. NEXRAD Principal User Process on left and antenna installation on right. The Navy has completed installation of the PUPS it has procured.

METMF Replacement

The Meteorological Mobile Facility Replacement program will provide a full range of weather support for Marine Air Ground Task Force (MAGTF) Expeditionary Operations. Government and commercial off-the-shelf (GOTS/COTS) technology enhancements are expected to allow miniaturization of all components into a single van versus the four vans that are now required for METMF. It will be deployable worldwide via C-130 sized airlift. The current schedule calls for 14 fully capable vans to be delivered beginning in FY 97. A fully integrated system, METMF(R) will consist of a TAC4 version of TESS (described in an earlier section); communication equipment for HF, VHF, UHF (line-of-sight), UHF/SATCOM communications, as well as SHF connectivity to a supporting communication unit; an AN/TMQ-43 satellite receiver, also known as the U.S. Air Force's Small Tactical Terminal (STT); an AN/UMQ- 12; one local and two remote sensor systems; Supplemental Weather Radar; and two MOSS (3) units, all housed within an environmentally controlled single shelter. Figure 7 is an artist's conception of METMF Replacement.

Initial Operating Capability is planned for the first quarter of FY 97 with the fielding of a single shelter equipped with each of the subsystems operating in stand-alone mode, and a TESS Remote Workstation (TRWS) for MAGTF C^4I/GCCS connectivity. Phase 2 of development will leverage fielding of the TAC4-based TESS, beginning in the first quarter of FY 98, and serve as

the data fusion center for the METMF(R) . Full Operational Capability is planned for FY 01 with the fielding of the last two of 14 shelters.

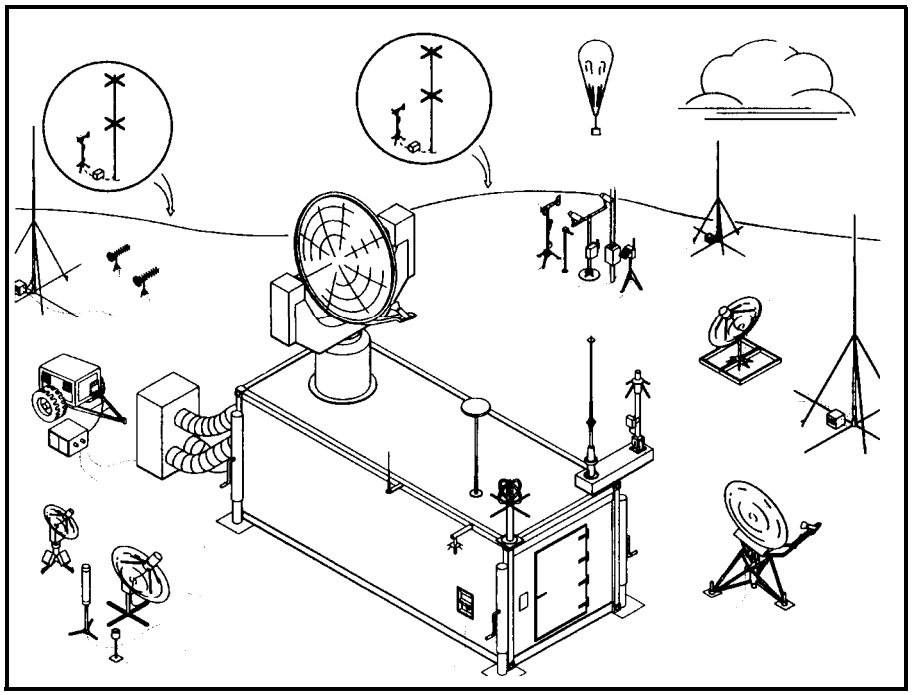

Figure 7. Artist's conception of the typical USMC METMF Replacement layout.

MRS

The AN/UMQ- 12, Mini-Rawin System employs 100 gram balloons to launch radiosondes which provide atmospheric elements such as temperature, dewpoint, pressure and winds to the receiver which automatically analyzes and codes the atmospheric data. These units represent one of the first efforts by the Navy to procure a system from commercially off-the-shelf hardware. MRS units have been successfully deployed aboard ship and at shore activities worldwide for over 10 years and have proven to be very accurate, reliable and cost effective. In 1995, PMW 185 procured two MRS systems with GPS capability for testing. The GPS capable sondes will provide more accurate data. Testing, which began in December 1995, continues aboard ship, but has been completed at shore sites. Preliminary results are promising, and it is anticipated that a contract will have been awarded by the time this article is published for procurement of 128 MRS conversion kits to be installed at all activities that have GPS capability. It is foreseen that these installations will be completed by October 1997.

GFO

Between 1985 and 1990, the Navy GEOSAT Mission demonstrated the capability of a satellite radar altimeter to provide global measurements of the absolute dynamic topography of mesoscale ocean features (fronts, eddies, and ice edge) to high precision. The GEOSAT Follow-on (GFO) program is designed to apply this experience to the benefit of the Navy until an operational altimeter is flown on NPOESS. Now scheduled for launch in 1997, GFO will

provide and maintain an operational source of altimetry data with high measurement precision and downlink data directly to the AN/SMQ-11 receiver/recorders aboard many Navy ships and CNMOC shore activities. Algorithms are being developed for use by the Altimetry Data Fusion Center in NAVOCEANO at the Stennis Space Center, MS and TESS/AN/SMQ-11 equipped ships to process the data to derive oceanographic features, such as currents, warm and cold eddies and sea heights.

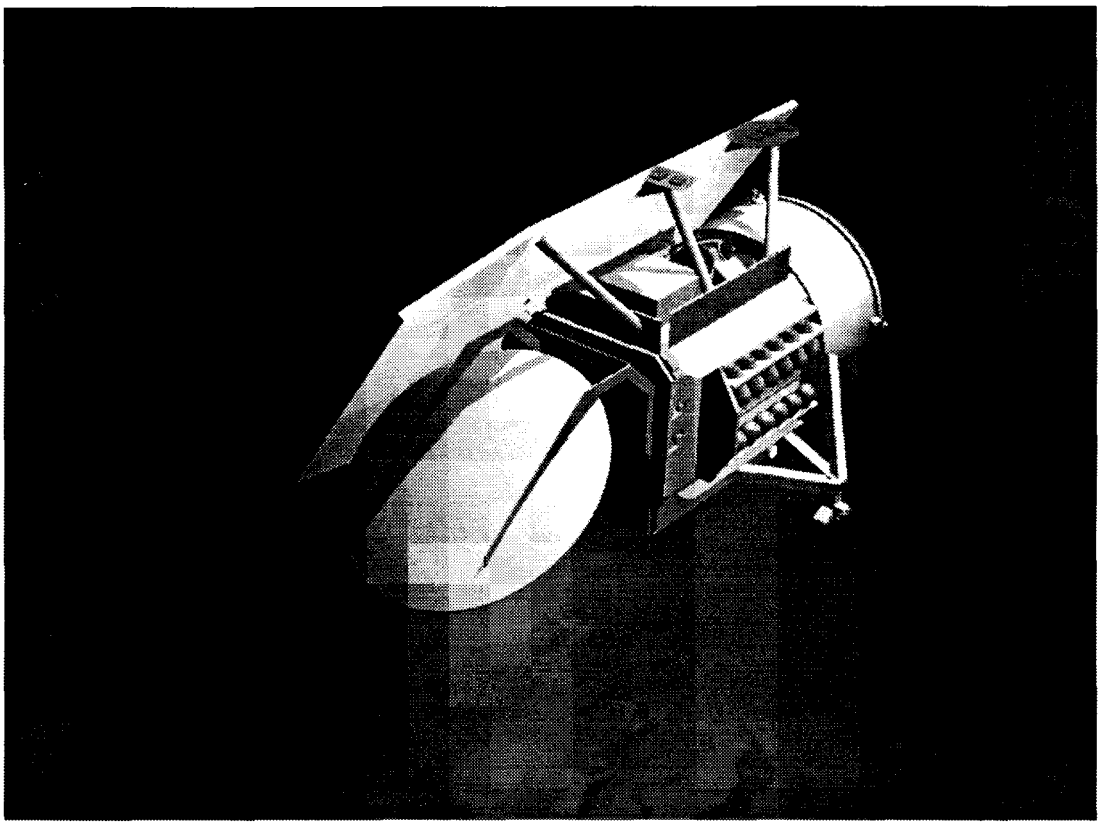

Figure 8. Artist's conception of the GFO spacecraft general layout.

DMSP

The Defense Meteorological Satellite Program (DMSP) helps ensure that Navy-unique sensor requirements are addressed both within DMSP and the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program which have been presidentially directed to consolidate. At this point, new spacecraft is planned to be launched in 2006. Developments within the current program include the calibration and validation of each Special Sensor Microwave Imager (SSM/I) that has been launched. Potential new sensors will likely include a new microwave imager, radar altimeter and scatterometer.

Precise Timing and Astrometry

The DoD assigns the Navy responsibility for coordinating precise time and time interval (PTTI) requirements and maintaining a PTTI reference standard. This responsibility is carried

out at the U. S. Naval Observatory in Washington, DC, where the master clock for the United States is maintained. In this thrust area, dem/val of new techniques for increasing master clock reliability and stability; improved time transfer by exploitation of satellites, fiber optics, etc.; upgraded earth orientation determination using GPS; new EO/IR telescope technology for improved reference frame determination and use of interferometry for precise astrometric positions are performed.

Atmospheric/Oceanographic Research Programs

PMW 185 oversees an expansive METOC R&D program that includes modeling, tactical systems development, satellite applications, and tactical decision aids. The Program Office also manages the Navy's METOC Satellite Programs under the resource sponsorship of the Director, Space and Electronic Warfare. In the area of METOC modeling, the Navy Operational Global Atmospheric Prediction System (NOGAPS) has been delivered and is operational at the Fleet METOC Numerical Center in Monterey, CA. In addition, the relocatable high resolution Navy Operational Regional Atmospheric Prediction System (NORAPS) is being developed to provide more accurate predictions over limited areas. The Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS) and a family of thermodynamic ocean circulation models, as well as data assimilation and quality control efforts are also currently under development.

Within the area of tactical systems development, demonstration, validation and engineering of METOC sensors (e.g., SMOOS Replacement), communication interfaces and processing and display equipment such as the AN/SMQ- 11 are being performed along with TESS hardware and software engineering. Important thrust areas in the satellite applications arena are tropical cyclone position and intensity algorithms and automated image analysis techniques. Other focuses include GFO processing and development of littoral zone analysis capabilities, as well as SAR exploitation within littoral regions. A family of tactical decision aids that capitalize on all of the above include EM/EO and Chem/Bio models, relocatable tide and surf models and a stand-alone tactical atmospheric and oceanographic forecasting capability. These latter efforts will eventually enable the organic METOC teams to develop their own limited forecasts even in the absence of data and products from the central computing sites.

SUMMARY

The METOC Systems Program Office, PMW 185, has responsibility for a wide variety of both operational and developmental efforts. Each of these has been conceived, developed and fielded with the intent of providing the METOC community with up-to-date tools of the trade so that they in turn may provide the best support possible to the tactical commanders afloat. Among other things, this requires close monitoring and testing of new technologies that might be exploited to improve existing capabilities. In this era of shrinking fiscal and personnel resources, the program office is also committed to seeking the most cost effective ways to deliver the best METOC products and data available.